General Introduction

Week 1, Lesson 1

- What is Physics
- Counting & Measuring: Accuracy & Precision
- Dimensions & Units of Measure
- Calculating & Converting
- Significant Digits

References/Reading Preparation:
Principles of Physics by Beuche – Ch.1

What is Physics?

Physics is: a body of knowledge that provide organized answer to our questions about the physical world.

Its goal : to describe all phenomena in the ohysical world in terms of a few fundamental realtionships (called the laws of Physics) between measurable properties of matter and energy.

All phenomena in the physical world → *Physical laws* → *Mathematical form* → *Quantitative results*

Counting & Measuring: Accuracy & Precision

Precision

One of the simplest methods of quantifying is to *count*.

This methods is applicable wherever we have individual units, such as apples, oranges, people,, or atoms.

In principle, counting is an exact process of quantifying because we are using whole numbers, or integers, to express a quantity.

Another method of quantifying is to *measure*.

Unlike counting, the process of measurement *is not* exact.

When we measure, we are no longer using integers to determine quantity. Instead, we are using the markings on a meter stick, or thermometer, or the ticks of a clock to measure quantities of length, temperature and time.

All such marks and ticks have an inherent limit of precision that is determined by the design and construction of the measuring device.

A general guideline is that a given measuring device has a limit of precision equal to one half the smallest division of measure-ment built into the device.

We use many devices to measure physical quantities, such as length, time, and temperature. Some are analog devices, some digital. They all have some limit of precision.

The limit of precision of a measuring device is ± ½ the smallest division of measurement the device is able to display.

Thus:

A meter stick with 1 mm divisions has a limiting precision of ±0.5 mm.

A vernier caliper that can be read to the nearest 0.1 mm has a limiting precision of ±0.05 mm.

A stopwatch with 0.5 second intervals has a precision of ±0.25 s.

A digital stopwatch that displays to the nearest 0.1 s has a limiting precision of ±0.05 s.

Accuracy

A different kind of measurement uncertainty involves the possibility of incorrect design or calibration of the instrument, or incorrect reading or interpretation of the instrument.

Such errors are called **systematic errors**.

These errors cause the measurement to be consistently higher or lower than the ***true value***.

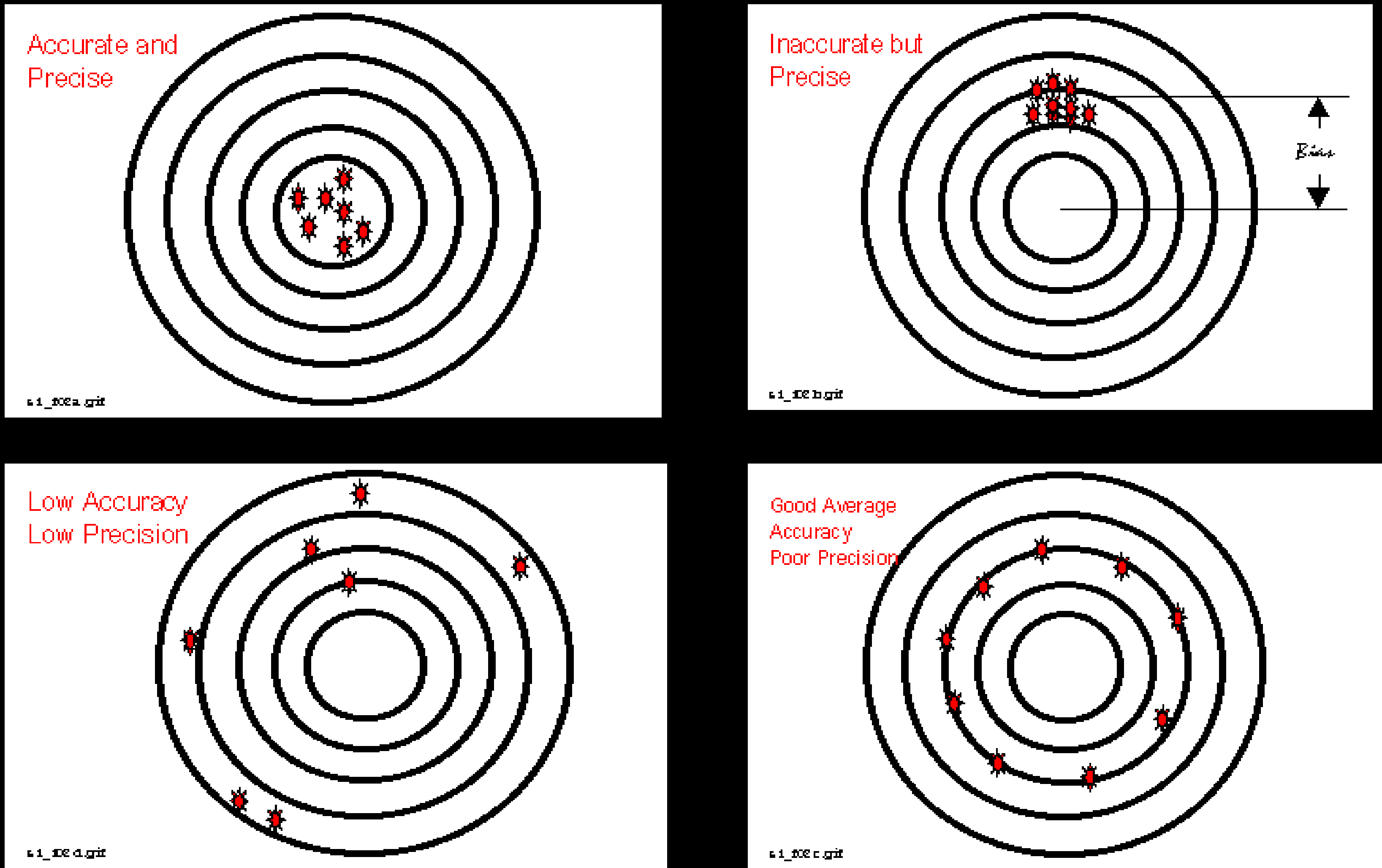
Such a measurement is said to be **inaccurate**.

Random errors or statistical errors

– Is multiple measurements of the same quantity using the same instrument often differ by more than the precision of the instrument.
- Caused by fluctuations on the physical property being measured. i.e: changes in temp, gas pressure, elec . voltage etc.
- It cannot be eliminated
- But can be reduced by increasing the number of measurements.

Accuracy is the extent to which systematic errors make a measured value differ from its true value.

Accuracy and Precision



Dimensions and Units in Measurement

When measuring a physical quantity, we first have to identify what ***kind*** of physical property we are measuring.

There are only seven basic kinds of physical properties necessary to describe all physical measurements.

These properties are called **dimensions**.

They are:

length mass time temperature electric current

number of particles luminous intensity

With each **dimension**, there is an associated **unit**.

The fundamental dimensions and their basic SI units are shown.

Dimension	**Unit**	**Symbol**
Length	meter	m
Mass	kilogram	kg
Time	second	s
Temperature	Kelvin	K
Electric current	Ampere	A
Number of Particles	Mole	M
Luminous Intensity	Candela	cd

Calculating with Units

Calculating with measured quantities involves two processes:

1) Doing the numerical calculation, and

2) Calculating the units of the resulting quantity.

Examples:

Dividing 60 miles (mi) by 2 hours (h) gives:

$$\frac{60\text{ mi}}{2\text{ h}} = 30\ \frac{\text{mi}}{\text{h}} = 30\text{ mi/h}$$

Multiplying 3 kilograms (kg) by 12 meters per second (m/s):

$$3\text{ kg} \times 12\text{ m/s} = 36\ \text{kg} \cdot \text{m/s}$$

Converting Between Systems of Units

The units used in various systems to measure a dimension usually have different names and represent different amounts of the dimension.

We can convert any measurement from one system to another by using the appropriate equivalencies, called ***conversion factors***.

For example: 1 ft = 0.3054 m

We read this as:

"there are 0.3054 meters in one foot (0.3054 m/1 ft)" or

"there is one foot in 0.3054 meters (1 ft/0.3054 m)"

Examples:

a) Convert 20.0 ft into meters.

b) Convert 60.0 mi/h to m/s.

(ans. 6.10 m, 26.8 m/s)

a) Convert 20.0 ft into meters.

1 ft = 0.3054 m

Therefore, 20 ft = 20 x 0.3054 = <u>6.108m</u>

b) Convert 60.0 mi/h to m/s.

1 mi/h → 1610m/3600s

Therefore, 60mi/h = (60 x 1610)/3600 m/s

= <u>26.83 m/s</u>

Converter:

1 inch=2.54cm

1 ounce=0.03 liter

1 ton= 1.016kg

Significant Digits in Calculations

Since measuring instruments always have a limit of precision and since statistical errors are often present, every measurement in physics has a limit on how many digits in the result are known with certainty.

The digits that are known with certainty are called **significant digits**.

Whenever you work a problem in physics, you must use the correct number of significant digits to express the results of both your measurement and your calculation.

Examples

Measurement	Significant Digits	Remarks
3.1 cm	2	
4.36 m/s	3	
5.003 mm	4	Both zeros are significant
0.00875 kg	3	Zeros simply locate the decimal.
8.75×10^{-3} kg	3	Same quantity as previous example.
4500 ft	2,3 or 4	Ambiguous – can't tell whether zeros measured or only showing decimal.

Significant Digits in Addition or Subtraction

When adding or subtracting measured quantities, the precision of the answer can only be as great as the ***least precise*** term in the sum or difference. All digits up to this limit of precision are significant.

Example:

3.76	cm
+ 46.855	cm
+ 0.2	cm
50.815	cm

The least precise quantity is 0.2 – so our answer is known only to the nearest 0.1 cm.

The correct answer is 50.8 cm.

Significant Digits in Multiplying and Dividing

When multiplying or dividing measured quantities, the number of significant digits in the result can only be as great as the least number of significant digits in any factor in the calculation.

Example:

(31.3 cm)(28 cm)(51.85 cm) = 45,441.34 cm^3

But, the significant digit rule allows us to keep only ***two*** digits – we are limited by the two significant digits in 28 cm.

Therefore, the answer is stated as: 45,000 cm^3, or 4.5×10^4 cm^3.

Homework

Read Sections 1.1 to 1.6 in **Principles of Physics**, by Beuche and Jerde.